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(54) IMAGE FORMING APPARATUS AND IMAGE FORMING METHOD

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CPC ***G03G 13/01*** (2013.01); ***G03G 15/0105*** (2013.01); ***G03G 15/5058*** (2013.01); *G03G 2215/0129* (2013.01); *G03G 2215/0161* (2013.01)

(58) **Field of Classification Search**
CPC G03G 13/01; G03G 15/0105
USPC 399/49, 72
See application file for complete search history.

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(57) **ABSTRACT**

An image forming apparatus includes: an image forming unit that forms a pattern image for image quality adjustment on an image carrier; a detection unit that detects the pattern image for the image quality adjustment; an image quality adjustment control unit that controls an image quality adjustment process in accordance with a result of detection of the detection unit; a reception unit that receives a color mode selected from among a plurality of kinds of color modes; and a calculation unit that calculates a total pattern length so that a total length of the pattern image for the image quality adjustment in a sub-scanning direction is equal in any of the color modes, wherein the image forming unit forms the pattern image for the image quality adjustment so that the total length of the pattern image for the image quality adjustment is equal to the calculated total pattern length.

9 Claims, 7 Drawing Sheets

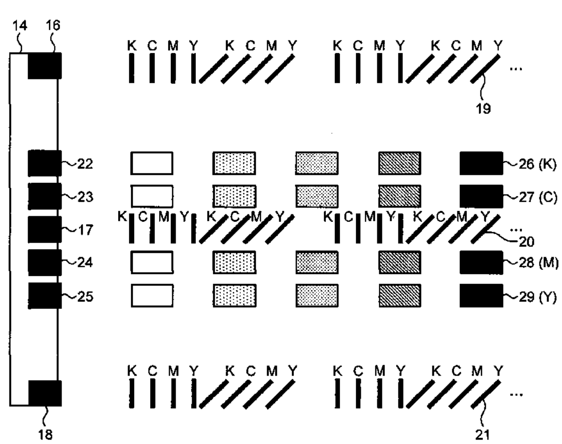

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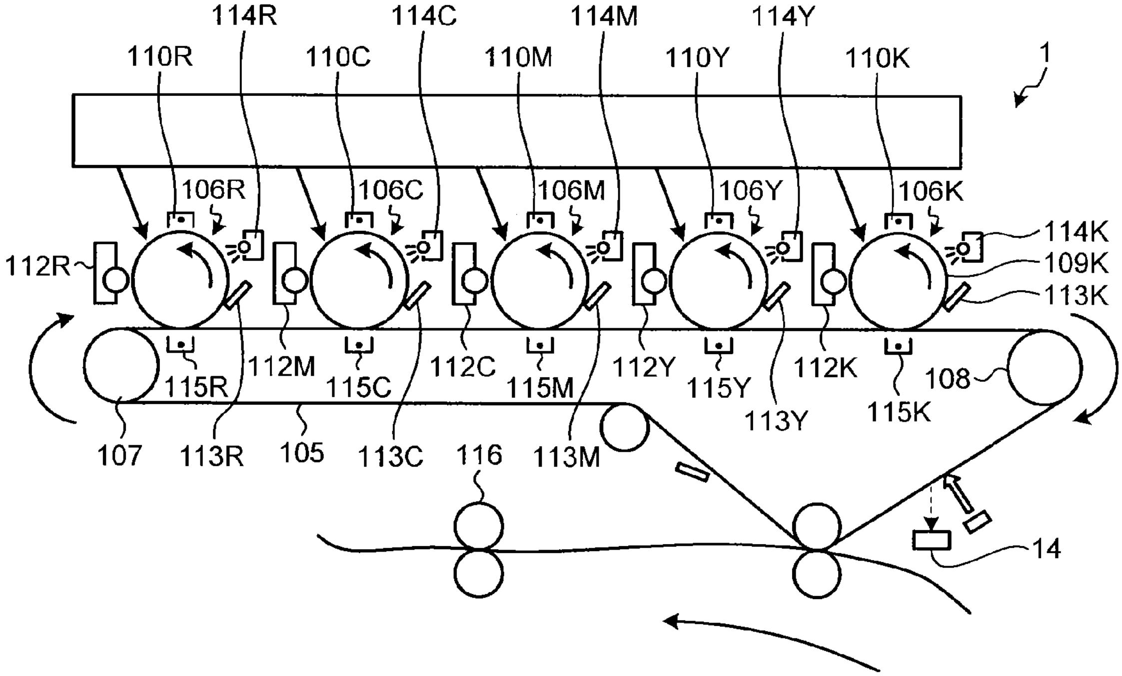
FIG.1



114R
114C
114M
114Y
110R
110C
110M
110Y
110K
1
106R
106C
106M
106Y
106K
114K
109K
113K
112R
112M
112C
112Y
112K
115R
115C
115M
115Y
115K
108
107
113R
105
113C
116
113M
113Y
14

FIG.2

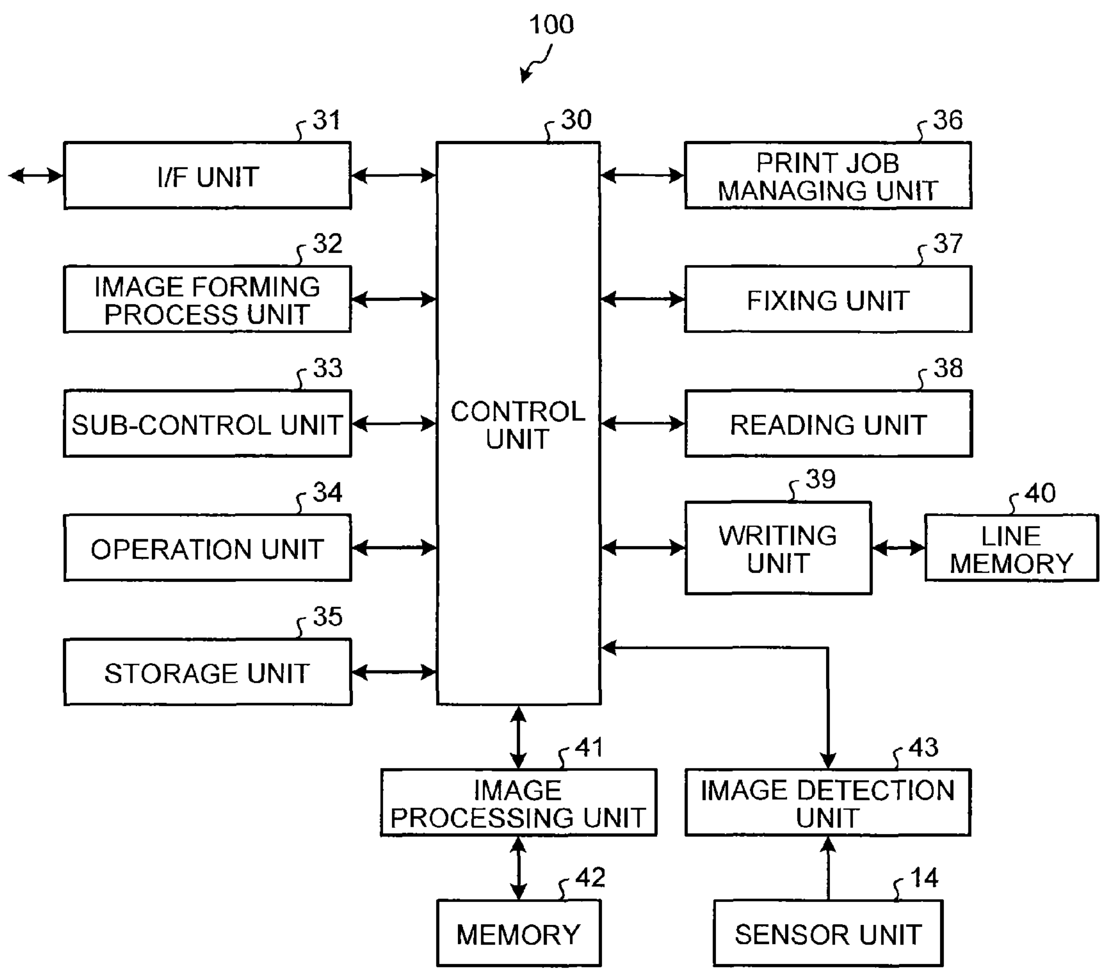

100
31
I/F UNIT
32
IMAGE FORMING PROCESS UNIT
33
SUB-CONTROL UNIT
34
OPERATION UNIT
35
STORAGE UNIT
30
CONTROL UNIT
36
PRINT JOB MANAGING UNIT
37
FIXING UNIT
38
READING UNIT
39
WRITING UNIT
40
LINE MEMORY
41
IMAGE PROCESSING UNIT
42
MEMORY
43
IMAGE DETECTION UNIT
14
SENSOR UNIT

FIG.3

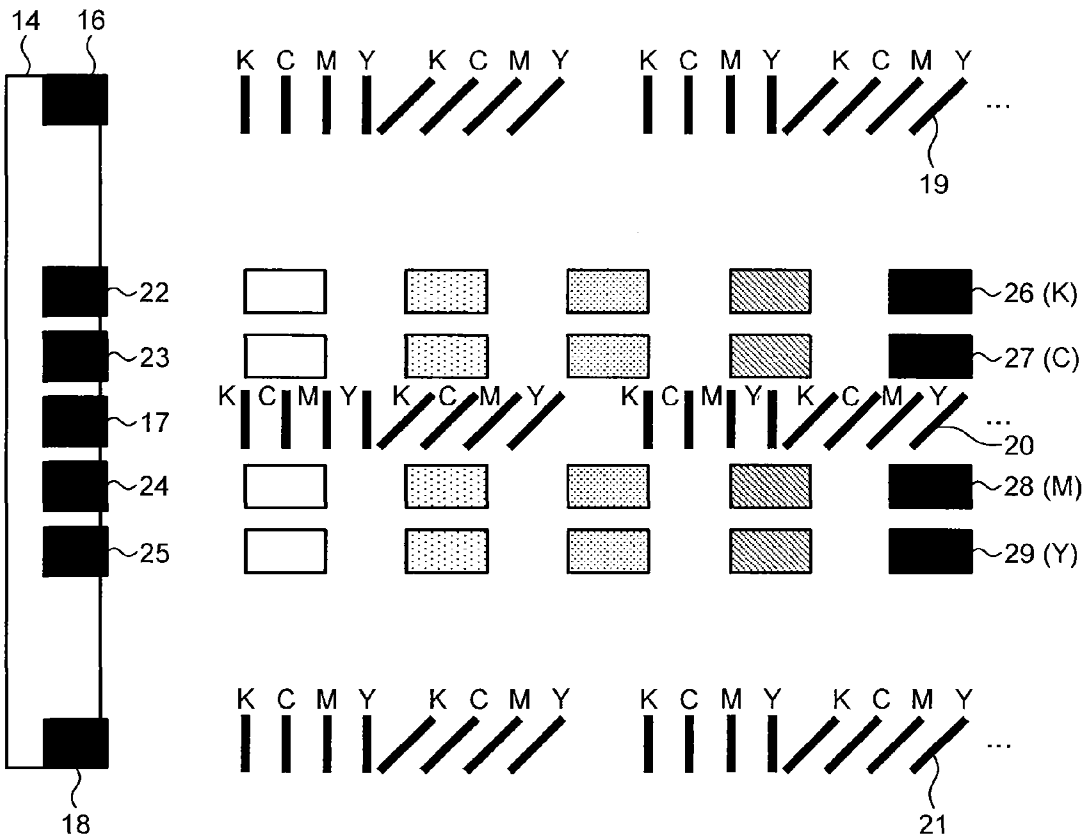

14
16
K C M Y K C M Y K C M Y K C M Y
...
19
22
23
17
24
25
K C M Y K C M Y K C M Y K C M Y
...
20
26 (K)
27 (C)
28 (M)
29 (Y)
K C M Y K C M Y K C M Y K C M Y
...
18
21

FIG.4

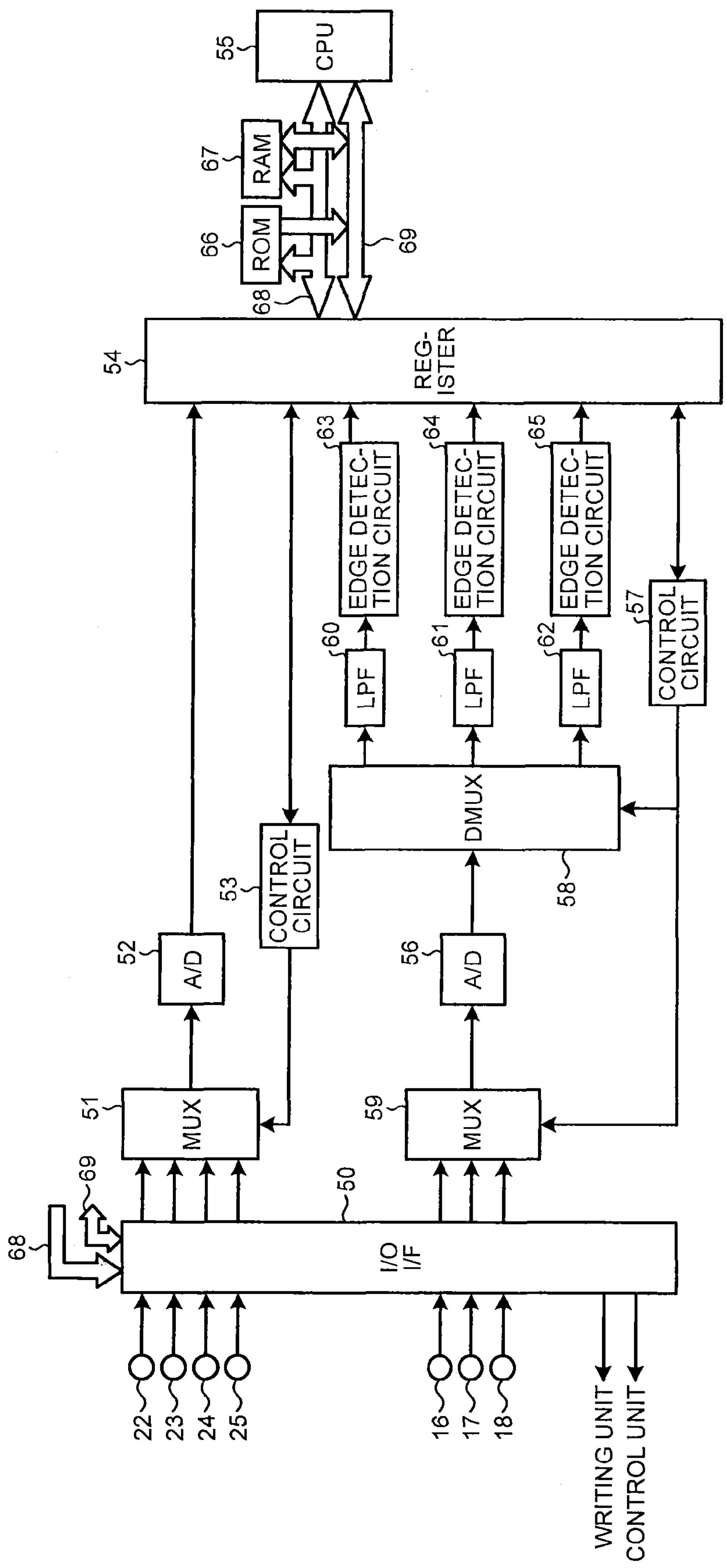
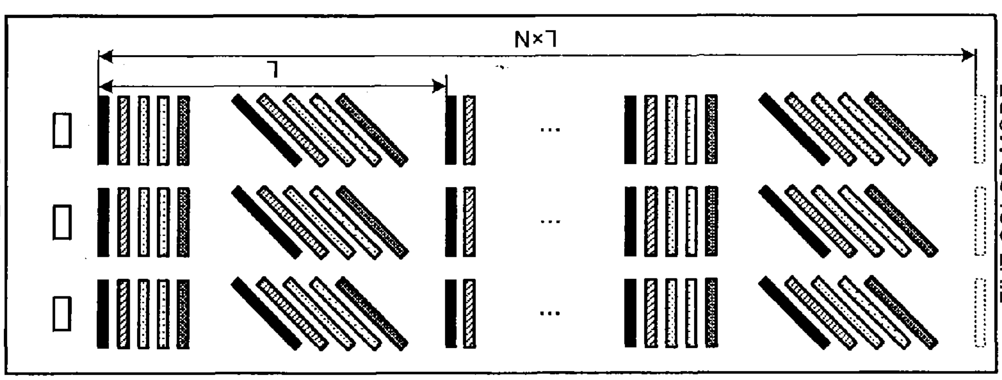
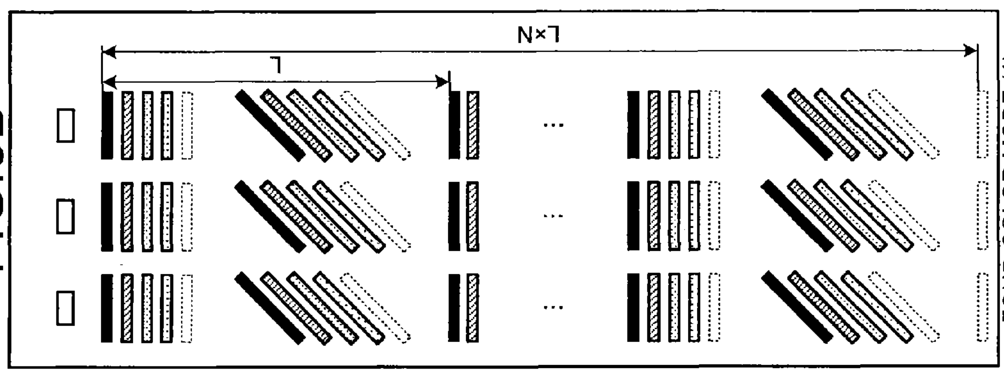

CPU
55
RAM
67
ROM
66
68
69
REG-
ISTER
54
EDGE DETEC-
TION CIRCUIT
63
64
65
LPF
60
61
62
CONTROL
CIRCUIT
57
DMUX
58
CONTROL
CIRCUIT
53
A/D
52
56
MUX
51
59
I/O
I/F
50
22
23
24
25
16
17
18
WRITING UNIT
CONTROL UNIT

FIG.5A



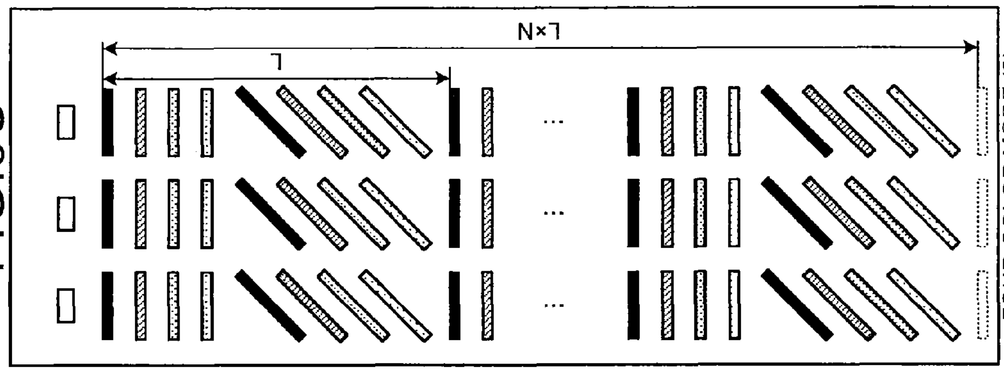
FIVE-COLOR MODE

FIG.5B



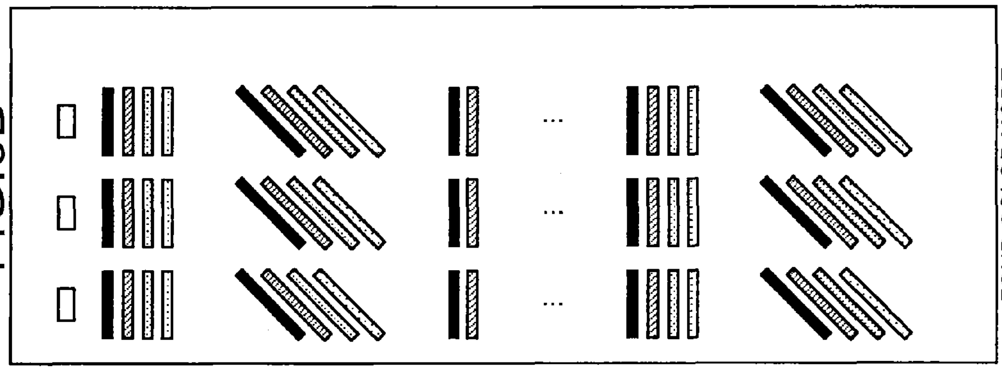
FOUR-COLOR MODE (1)

FIG.5C



FOUR-COLOR MODE (2)

FIG.5D



FOUR-COLOR MODE

FIG.6

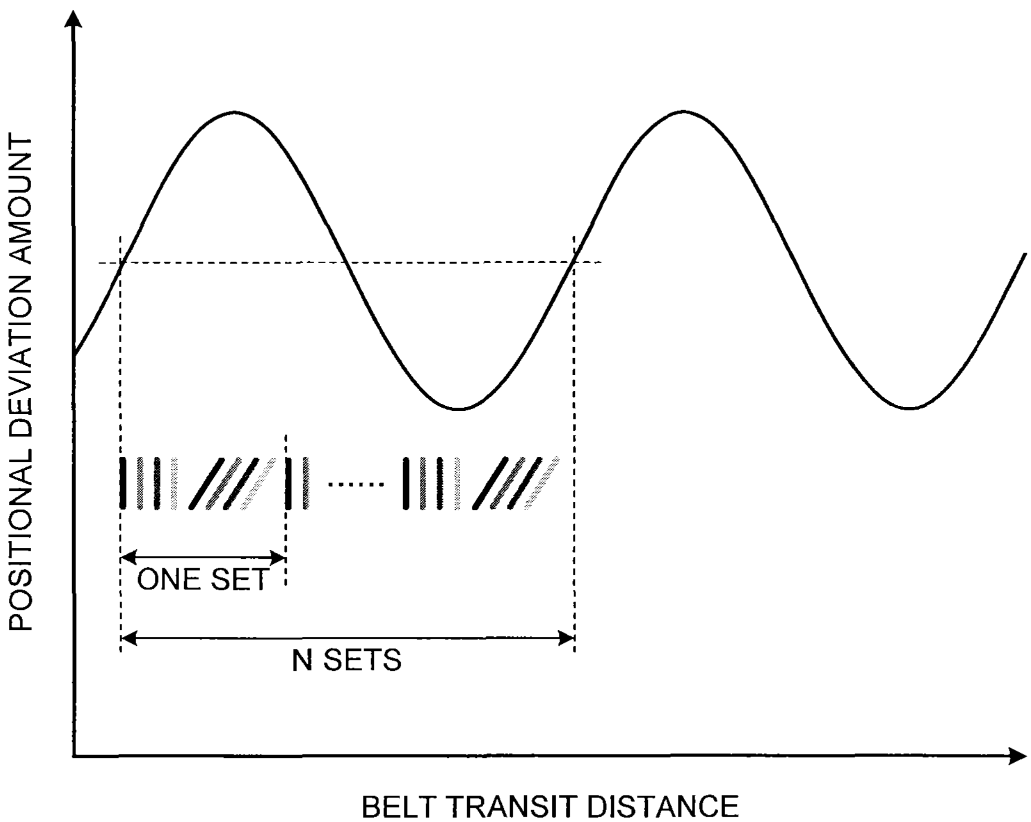

POSITIONAL DEVIATION AMOUNT
ONE SET
N SETS
BELT TRANSIT DISTANCE

FIG.7A

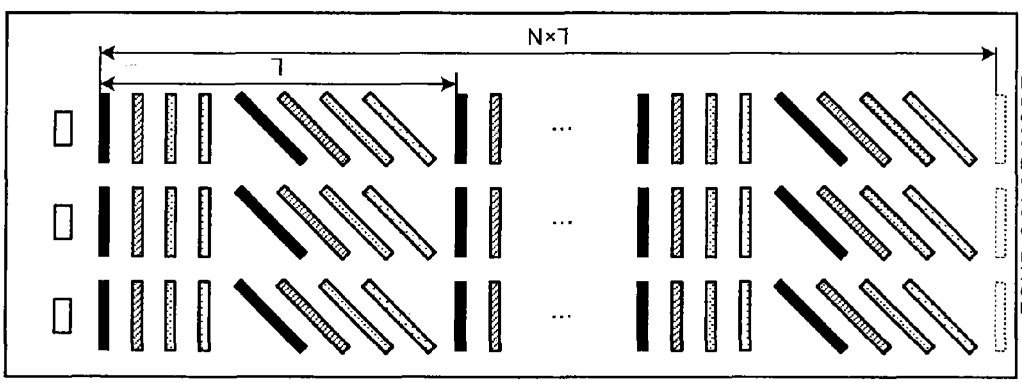


FIG.7B

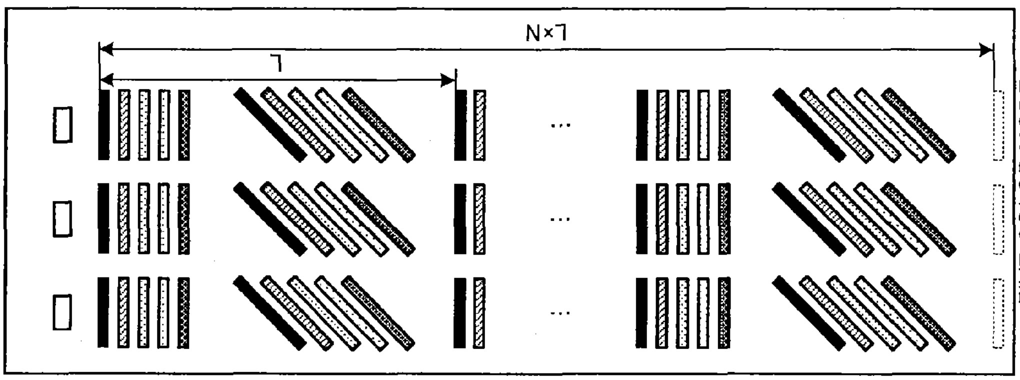


FIG.7C

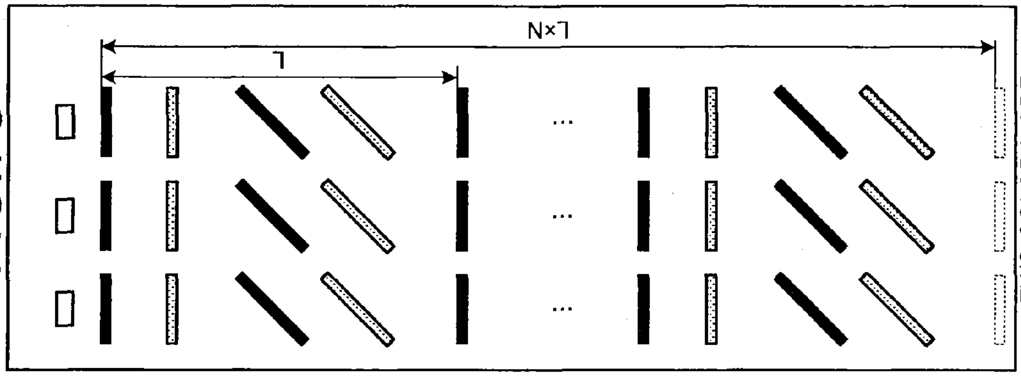


IMAGE FORMING APPARATUS AND IMAGE FORMING METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority to and incorporates by reference the entire contents of Japanese Patent Application No. 2012-198818 filed in Japan on Sep. 10, 2012.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an image forming apparatus and an image forming method.

2. Description of the Related Art

As an electrophotography image forming apparatus, a tandem type image forming apparatus having a plurality of photosensitive elements for forming images with different colors from each other has become popular. In this tandem type image forming apparatus, an electrostatic latent image is formed by optical writing on a photosensitive element and a toner image formed by developing this electrostatic latent image is transferred to a printing medium or an intermediate transfer body. This transfer operation is performed for each color, and the toner images of the colors are overlapped on the printing medium or the intermediate transfer body, thereby providing a full-color toner image. In the case of having transferred the toner image to the intermediate transfer body, the toner image is further transferred from the intermediate transfer body to the printing medium. The toner image transferred to the printing medium is fixed on the printing medium, thereby providing the color image.

The positional deviation among the color transfer positions in such an image forming apparatus leads to the deterioration in image quality of the printing image because the color toner images are not overlapped with each other correctly. Therefore, it is necessary to correct the positional deviation among the color transfer positions.

As a method of correcting the positional deviation among the color transfer positions (hereinafter referred to as the positional deviation for short) in the electrophotography image forming apparatus, a method is known in which a positional deviation correction pattern is formed on an intermediate transfer body, a carriage belt for conveying a printing medium, or the like and the positional deviation correction is performed based on the positional information obtained by detecting the position of the positional deviation correction pattern with a sensor.

Japanese Laid-open Patent Publication No. 2011-112704 discloses an image forming apparatus including toner of two special colors in addition to general toner of four colors. In this image forming apparatus, the positional deviation correction pattern to be formed varies depending on the number of colors.

If a pattern image is formed based on one color mode out of mode performing color match control with only four colors and mode performing color match control with five or more colors, a pattern image is formed in the other color mode based on the formed pattern image. As a result, since the number of toner is different, the total pattern length varies. In that case, even though the positional deviation correction is performed based on the patter image formed according to one color mode, the total pattern length is different in the other color mode, in which case the positional deviation correction cannot be performed as appropriate.

Therefore, it is desirable to provide an image forming apparatus capable of performing positional deviation correction as appropriate on any of a plurality of color modes.

SUMMARY OF THE INVENTION

It is an object of the present invention to at least partially solve the problems in the conventional technology.

According to an aspect of the present invention, there is provided an image forming apparatus including: an image forming unit that forms a pattern image for image quality adjustment on an image carrier; a detection unit that detects the pattern image for the image quality adjustment; an image quality adjustment control unit that controls an image quality adjustment process in accordance with a result of detection of the detection unit; a reception unit that receives a color mode selected from among a plurality of kinds of color modes whose number of colors used for forming an image is different; and a calculation unit that calculates a total pattern length so that a total length of the pattern image for the image quality adjustment in a sub-scanning direction is equal in any of the color modes, wherein the image forming unit forms the pattern image for the image quality adjustment so that the total length of the pattern image for the image quality adjustment is equal to the calculated total pattern length.

According to another aspect of the present invention, there is provided an image forming method including: forming, by an image forming unit, a pattern image for image quality adjustment on an image carrier; detecting, by a detection unit, the pattern image for the image quality adjustment; controlling, by an image quality adjustment control unit, an image quality adjustment process in accordance with a result of detection of the detection unit; receiving, by a reception unit, a color mode selected from among a plurality of kinds of color modes whose number of colors used for forming an image is different; and calculating, by a calculation unit, a total pattern length so that a total length of the pattern image for the image quality adjustment in a sub-scanning direction is equal in any of the color modes, wherein the forming the pattern image includes forming the pattern image for the image quality adjustment so that the total length of the pattern image for the image quality adjustment is equal to the calculated total pattern length.

According to still another aspect of the present invention, there is provided an apparatus including: image forming means for forming a pattern image for image quality adjustment on an image carrier; detection means for detecting the pattern image for the image quality adjustment; image quality adjustment control means for controlling an image quality adjustment process in accordance with a result of detection of the detection means; reception means for receiving a color mode selected from among a plurality of kinds of color modes whose number of colors used for forming an image is different; and calculation means for calculating a total pattern length so that a total length of the pattern image for the image quality adjustment in a sub-scanning direction is equal in any of the color modes, wherein the image forming means form the pattern image for the image quality adjustment so that the total length of the pattern image for the image quality adjustment is equal to the calculated total pattern length.

The above and other objects, features, advantages and technical and industrial significance of this invention will be better understood by reading the following detailed description of presently preferred embodiments of the invention, when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram depicting an image forming apparatus of a first embodiment;

FIG. **2** is a block diagram depicting a functional structure of the first embodiment;

FIG. **3** is a diagram depicting an example of a pattern image of the first embodiment;

FIG. **4** is a circuit diagram depicting a hardware structure of the first embodiment;

FIGS. **5**A to **5**D are diagrams depicting examples of a pattern image of the first embodiment;

FIG. **6** is a diagram depicting the relation between the drive period and the total length of the pattern image of the first embodiment; and

FIGS. **7**A to **7**C are diagrams depicting examples of a pattern image of a third embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

First Embodiment

FIG. **1** mainly depicts a part performing image formation in one example of an image forming apparatus according to a first embodiment. An image forming apparatus **1** depicted in FIG. **1** is of so-called tandem type having a structure in which image forming units **106**C, **106**M, **106**Y, **106**K, and **106**R for forming images of C (Cyan), M (Magenta), Y (Yellow), K (Black), and special color R (Red) are arranged along a carriage belt **105**. This first embodiment describes an example of a direct transfer type image forming apparatus for directly transferring an image to a printing medium from a photosensitive drum which has been subjected to exposure in accordance with image data.

In this image forming apparatus **1**, the image forming units **106**K, **106**Y, **106**M, **106**C, and **106**R are arranged in this order from the upstream side of the conveying direction of this carriage belt **105** along the carriage belt **105** for conveying paper (printing medium). These image forming units **106**K, **106**Y, **106**M, **106**C, and **106**R have a common internal structure except that the colors of the formed toner images are different.

In other words, for example, the image forming unit **106**K includes a photosensitive drum **109**K, a charger **110**K, a developing unit **112**K, a neutralizer **113**K, and a LEDA (light-emitting diode array) head **114**K, and has a transferring unit **115**K at a position opposite to the carriage belt **105** relative to the photosensitive drum **109**K.

Similarly, the image forming units **106**Y, **106**M, **106**C, and **106**R include a photosensitive drum **109**Y, a photosensitive drum **109**M, a photosensitive drum **109**C, and a photosensitive drum **109**R, a charger **110**Y, a charger **110**M, a charger **110**C, and a charger **110**R, a developing unit **112**Y, a developing unit **112**M, a developing unit **112**C, and a developing unit **112**R, a neutralizer **113**Y, a neutralizer **113**M, a neutralizer **113**C, and a neutralizer **113**R, and a LEDA head **114**Y, a LEDA head **114**M, a LEDA head **114**C, and a LEDA head **114**R, respectively. Moreover, the image forming units **106**Y, **106**M, **106**C, and **106**R include transferring units **115**Y, **115**M, **115**C, and **115**R at positions opposite to the carriage belt **105** relative to the photosensitive drum **109**Y, the photosensitive drum **109**M, the photosensitive drum **109**C, and the photosensitive drum **109**R, respectively.

The description is hereinafter made basically of the image forming unit **106**K representing the image forming units **106**K, **106**Y, **106**M, **106**C, and **106**R for avoiding complication.

The carriage belt **105** is an endless belt wound around a driving roller **107**, which is driven to rotate, and a driven roller **108**. This driving roller **107** is driven to rotate by a driving motor, which is not illustrated. This driving motor, the driving roller **107**, and the driven roller **108** serve as a driving unit for moving the carriage belt **105**.

For forming an image, the paper housed in a paper feeding tray is fed in order from the uppermost sheet by a paper feeding roller, and after the end of paper is sensed by a registration sensor for paper alignment, the paper is fed into a separation roller. Upon the reach of the paper at the carriage belt **105** after being sent out from the separation roller, the paper is suck on the carriage belt **105** due to an electrostatic suction operation, and the paper is conveyed to the first image forming unit **106**K by the carriage belt **105**, which is driven to rotate, where the black toner image is transferred.

The image forming unit **106**K includes the photosensitive drum **109**K as a photosensitive element, the charger **110**K disposed around the photosensitive drum **109**K, the LEDA head **114**K, the developing unit **112**K, a photosensitive cleaner (not illustrated), and the neutralizer **113**K. The LEDA head **114** is configured, for example, with a number of laser diodes arranged so that the photosensitive drum **109**K is irradiated with a laser beam linearly in a main-scanning direction.

For forming an image, the outer peripheral surface of the photosensitive drum **109**K is uniformly charged by the charger **110**K in darkness and then irradiated with irradiation light in accordance with image data from the LEDA head **114**K, thereby forming an electrostatic latent image. The developing unit **112**K visualizes this electrostatic latent image with black toner. Thus, the black toner image is formed on the photosensitive drum **109**K.

Here, the photosensitive drum **109**K is exposed to light for one line with one lighting of the LEDA head **114**K, thereby performing one scanning in the main-scanning direction. The exposure of lines at equal intervals is performed by rotating the photosensitive drum **109**K at predetermined angular velocity and turning on the LEDA head **114**K in a predetermined period.

The toner image formed on the photosensitive drum **109**K is transferred onto paper on the carriage belt **105** by the operation of the transferring unit **115**K at a position (transfer position) where the photosensitive drum **109**K is in contact with the paper. Through this transfer, the black toner image is formed on the paper.

The photosensitive drum **109**K on which the toner image has been transferred is neutralized by the neutralizer **113**K after the unnecessary toner remaining on the outer peripheral surface is removed with the photosensitive cleaner; then, the photosensitive drum **109**K stands-by for the next image formation.

Thus, the paper on which the black toner image has been transferred in the image forming unit **106**K is transferred to the next image forming unit **106**Y by the carriage belt **105**. In the image forming unit **106**Y, a yellow toner image is formed on the photosensitive drum **109**Y through a similar process to the image forming process in the image forming unit **106**K, and this toner image is overlapped on and transferred to the black image formed on the paper. The paper is sequentially conveyed to the next image forming units **106**M, **106**C, and **106**R, and through the similar process, a magenta toner image formed on the photosensitive drum **109**M, a cyan toner image formed on the photosensitive drum **109**C, and a red toner image formed on the photosensitive drum **109**R are sequentially overlapped on and transferred to the paper. Thus, a full-color image is formed on the paper.

The paper having the full-color image formed thereon is separated from the carriage belt **105** and fed into a fixing unit **116**. The fixing unit **116** includes a fixing roller and a pressing roller in contact with the fixing roller, and is configured so that the pressing roller applies a predetermined amount of pressure to the fixing roller. The fixing roller is controlled to be heated at certain temperature by a heater, which is not illustrated. At least one of the fixing roller and the pressing roller is driven to rotate at angular velocity corresponding to the conveying velocity of the carriage belt **105**.

The paper is heated and pressed when the paper passes between a fixing roller **123***a* and a pressing roller **123***b*. By this heating and pressing, the toner images of the respective colors on the paper are fixed on the paper. The paper discharged from the fixing unit **116** is discharged after an end of the paper is sensed by a discharging sensor which senses the presence of paper utilizing the light reflection, for example.

Note that the image forming apparatus **1** according to the first embodiment forms the positional deviation correction pattern relative to the carriage belt **105** for correcting the positional deviation of the image to be formed. A sensor unit **14** for detecting the positional deviation correction pattern provided for the carriage belt **105** is provided on the downstream side of the driving direction of the carriage belt **105** of the photosensitive drums **109**C, **109**M, **109**Y, **109**K, and **109**R.

The sensor unit **14** is disposed in a predetermined direction, and is disposed, for example, in a manner of being aligned in a direction orthogonal to the driving direction of the carriage belt **105**.

FIG. **2** is a function block diagram depicting one example of a configuration for controlling the image forming apparatus **1** according to the first embodiment. The image forming apparatus **1** includes a control unit **30**, an I/F (interface) unit **31**, an image forming process unit **32**, a sub-control unit **33**, an operation unit **34**, a storage unit **35**, a print job managing unit **36**, a fixing unit **37**, a reading unit **38**, a writing unit **39**, an image processing unit **41**, and image detection unit **43**.

The control unit **30** includes, for example, a CPU (Central Processing Unit), ROM (Read Only Memory), and RAM (Random Access Memory), and controls the entire image forming apparatus using the RAM as work memory in accordance a program stored in the ROM. The control unit **30** has an arbitration unit for arbitrating the data transfer on a bus, and controls the data transfer among the aforementioned units.

The I/F unit **31** is connected to an external device such as a personal computer, and controls the communication with the external device in accordance with the order of the control unit **30**. For example, upon the reception of a print request or the like transmitted from an external device, the I/F unit **31** sends the request to the control unit **30**. The print job managing unit **36** manages the order of printing on the print request (print job) requested to the image forming apparatus.

The image processing unit **41** is connected to a memory **42**, and for example, the image data sent from the sub-control unit **33** are stored in the memory **42** once, and the image data stored in the memory **42** are subjected to predetermined image processing. The image data on which the image processing has been performed are stored in the memory **42** again. The image processing unit **41** can generate predetermined image data in accordance with the order of the control unit **30**.

The sub-control unit **33** includes a CPU, for example, and controls each unit depicted in FIG. **1** in accordance with the print request, and moreover sends the image data for printing, which has been transmitted from the external device via the I/F unit **31**, to the image processing unit **41**. The sub-control unit **33** receives the image data after the image processing or the generated image data from the image processing unit **41** and sends the data to the writing unit **39**, which is described later.

The writing unit **39** receives the image data from the sub-control unit **33**, and controls the writing, i.e., exposure in accordance with the image data relative to the photosensitive drums **109**C, **109**M, **109**Y, **109**K, and **109**R with the LEDA heads **114**C, **114**M, **114**Y, **114**K, and **114**R in the image forming units **106**C, **106**M, **106**Y, **106**K, and **106**R.

The writing unit **39** is connected to a line memory **40** capable of storing the image data for a plurality of lines per unit line. For example, the writing unit **39** stores the image data received from the sub-control unit **33** in the line memory **40** per unit line. On this occasion, the writing unit **39** is provided with the image processing unit so that the image data to be stored in the line memory **40** can be subjected to predetermined image processing.

The writing unit **39** reads out the image data from the line memory **40** per unit line in accordance with the control by the control unit **30**, and writes the image data to the photosensitive drums **109**C, **109**M, **109**Y, **109**K, and **109**R by controlling the lighting of the LEDA heads **114**C, **114**M, **114**Y, **114**K, and **114**R per unit pixel on the basis of the readout image data.

The image forming process unit **32** includes the aforementioned image forming units **106**C, **106**M, **106**Y, **106**K, and **106**R, and performs processes such as developing and transferring of the electrostatic latent images written in the photosensitive drums **109**C, **109**M, **109**Y, **109**K, and **109**R by the writing unit **39**.

The image detection unit **43** (detector) is connected to the sensor unit **14**, and based on the output of the sensor unit **14**, the detector detects the positional deviation correction pattern formed on the carriage belt **105** with the writing unit **39** in accordance with the control of the control unit **30**. The result of detecting the positional deviation correction pattern is sent to the control unit **30**. Based on the result of detecting the positional deviation correction pattern, the control unit **30** controls the writing unit **39** to perform the positional deviation correction process.

The storage unit **35** stores the information representing the state of the image forming apparatus **1** at a certain time. For example, the result of detecting the positional deviation correction pattern is stored in the storage unit **35** in response to interruption caused by the control unit **30**. The operation unit **34** includes an operator for receiving the user operation and a display unit for displaying the state of the image forming device **1** to a user.

The fixing unit **37** has the fixing unit **116** and a structure for controlling the fixing unit **116**, and fixes the toner image on the paper by heating and pressing the paper on which the toner image has been transferred by the image forming process unit **32**.

The reading unit **38** reads out the print information on the paper and converts the information into electric signals, and achieves a so-called scanner function. The electric signals which have been read out by the reading unit **38** and output are transferred to the control unit **30**. This reading unit **38** and a communication unit, which is not illustrated, allow the image forming apparatus **1** to function as a multifunctional printer, which is a single body achieving the printing function, the scanning function, the copying function, and the FAX function. Note that the reading unit **38** can be omitted.

FIG. **3** depicts the detailed configuration of the sensor unit **14**. As depicted in FIG. **3**, in this embodiment, a process control pattern and a positioning pattern of each color are formed on the carriage belt **105**, and these patterns are detected by the sensor unit **14**. Note that the patterns may alternatively be formed on the intermediate transfer belt. Although the patterns in the drawing are formed based on four colors, the patterns can have another mode depending on the number of colors used.

The sensor unit **14** is provided with positioning sensors **16**, **17**, and **18** in the main-scanning direction, and the positioning sensors **16**, **17**, and **18** detect positioning patterns **19**, **20**, and **21**, respectively. The sensor unit **14** is provided with detection sensors **22**, **23**, **24**, and **25** for detecting the process control patterns, and the sensors **22**, **23**, **24**, and **25** detect patterns **26**(K), **27**(C), **28**(M), and **29**(Y) arranged in parallel, respectively. The positioning patterns **19**, **20**, and **21** are formed by combining horizontal line patterns, which are formed by arranging lines of colors Y, K, M, and C are disposed at equal intervals in parallel to the main-scanning direction, and oblique line patterns, which are formed by arranging the color lines at equal intervals at an angle of 45° from the main-scanning direction.

Hereinafter, each of the color lines included in the positioning patterns **19**, **20**, and **21** is referred to as a toner mark. In other words, the positioning patterns **19**, **20**, and **21** are the positional deviation correction patterns each corresponding to a group of the toner marks.

The positioning patterns **19**, **20**, and **21** are formed in a plurality of rows in the main-scanning direction, i.e., the width direction relative to the carriage belt **105** as depicted in FIG. **3**. For example, the image processing unit **41** generates the image data for forming the positioning patterns **19**, **20**, and **21** in accordance with the order of the control unit **30**, and the image data are stored in the memory **42**. Therefore, in this embodiment, the image processing unit **41** functions as the image forming unit.

The control unit **30** controls the image forming process unit **32** and the writing unit **39** on the basis of the image data stored in the memory **42** to form the electrostatic latent images of the positioning patterns **19**, **20**, and **21** on the photosensitive drums **109**C, **109**M, **109**Y, and **109**K. The electrostatic latent images are developed to form the toner images, and the toner images of the positioning patterns **19**, **20**, and **21** are transferred onto the carriage belt **105**.

The number of the positioning patterns **19**, **20**, and **21** in each row is more than one in the sub-scanning direction, i.e., the direction where the carriage belt **105** runs. One positioning pattern **19**, one positioning pattern **20**, and one positioning pattern **21** are regarded as one set, and for example, eight sets of the positioning patterns **19**, **20**, and **21** are formed in each row.

Next, an example of a method of correcting the positional deviation which can be applied to the first embodiment is described. In this embodiment, a correction value based on which the control unit **30** performs the positional deviation correction is calculated by measuring the distance between the toner marks included in the horizontal line patterns of the positioning patterns **19**, **20**, and **21** and the distance between each toner mark of the horizontal line pattern and each toner mark of the oblique line pattern.

In this example, the positioning patterns **19**, **20**, and **21** are formed repeatedly in the sub-scanning direction at each end of the carriage belt **105** in the main-scanning direction, and two rows of the positional deviation correction patterns are formed. The distance from the head toner mark (toner mark of the color K of the horizontal line pattern) among the positioning patterns **19**, **20**, and **21** to the head toner mark of the positioning patterns **19**, **20**, and **21** disposed next to the above positioning patterns **19**, **20**, and **21** corresponds to the length of the positioning patterns **19**, **20**, and **21**. The positional deviation correction pattern rows including the positioning patterns **19**, **20**, and **21** are sensed by the positioning sensors **16**, **17**, and **18**, respectively, so that the control unit **30** (image quality adjustment control unit) performs the positional deviation correction process.

In the positioning patterns **19**, **20**, and **21**, the results of sensing the toner marks included in the horizontal line patterns and the oblique line patterns by the positioning sensors **16**, **17**, and **18** are sampled at a certain sampling interval, and the time interval at which the toner marks in the horizontal line patterns and the oblique line patterns are sensed is measured. By multiplying the measured time interval by the known velocity of the carriage belt **105**, the distance between the toner marks included in the horizontal line patterns and the oblique line patterns can be acquired. Moreover, by measuring the distance between the toner marks with the same color in the horizontal line patterns and the oblique line patterns and comparing the distance between the colors, the positional deviation amount can be obtained. As a specific calculation method, the interval of the toner marks in the horizontal line patterns and the oblique line patterns of the color K is measured with the positioning sensor **16** and the difference from the ideal interval of the toner marks in the horizontal line patterns and the oblique line patterns is calculated; then, the calculation result is assumed as A [mm]. Moreover, the interval of the toner marks in the horizontal line patterns and the oblique line patterns of the color K is measured with the positioning sensor **18** and the difference from the ideal interval of the toner marks in the horizontal line patterns and the oblique line patterns is calculated; then, the calculation result is assumed as B [mm]. Since the inclination of the oblique line is 45°, the calculation result corresponds to the positional deviation amount in the main-scanning direction at each sensor position. Accordingly, when the interval between the positioning sensor **16** and the positioning sensor **18** is D [mm], (D+B−A)/D corresponds to the proportion of the main-scanning magnification error.

Next, description is made of the positioning process and the process control process with reference to the block diagram of FIG. **4**. The detection voltage generated when the detection sensors **22**, **23**, **24**, and **25** for the process control pattern have detected the patterns is input to a multiplexer **51** via an I/O interface **50**. A control circuit **53** controls the multiplexer **51** and an A/D converter **52** so that the selection of a sensor ch and A/D conversion operation are performed only during the pattern formation, and the obtained digital data are stored in a register **54**. A CPU **55** changes the process conditions for the charging, development, the transfer, and the like depending on the obtained data.

Upon the detection of the pattern, the positioning sensors **16**, **17**, and **18** output the detection voltage to a multiplexer **59** via the I/O interface **50**. A control circuit **57** controls the multiplexer **59** and an A/D converter **56** so that the selection of a sensor ch and A/D conversion operation are performed only during the pattern formation, and the obtained digital data are input in a demultiplexer **58**. The demultiplexer **58** selects to which of LPF circuits (digital filter circuit: product-sum operation circuit) **60**, **61**, and **62** prepared for each sensor ch the converted digital data are output. The LPF circuits **60**, 61, and 62 cut the high-frequency component, so that a pattern position can be recognized more correctly by a post-stage circuit.

Edge detection circuits 63, 64, and 65 on the downstream side of the LPF circuits 60, 61, and 62 compare the waveform of the detection voltage with a predetermined threshold voltage, and extracts the rise/drop points. The center thereof is recognized as the pattern central position and is stored in the register 54. Based on the data stored in the register 54, the CPU 55 performs change calculation and setting of the process conditions, and calculation and setting of the positioning, while storing data in a RAM 67 in accordance with the program stored in a ROM 66. The setting is transmitted to the writing unit 39 and the control unit 30 via the I/O interface 50. The I/O interface 50 is connected to the ROM 66 and the RAM 67 with an address bus 68 and a data bus 69.

The CPU 55 performs operation such as sampling start/stop and switching of sensor ch for A/D conversion with the control circuits 53 and 57 by changing the setting value of the register 54. Moreover, by changing the setting value of the register 54, the CPU 55 changes the cutoff frequency of the LPF circuits 60, 61, and 62. Further, by changing the setting value of the register 54, the CPU 55 sets the threshold voltage of the edge detection circuits 63, 64, and 65.

Therefore, the calculation process performed using the hardware for positioning control is achieved by: performing a product-sum operation with the LPF circuits 60, 61, and 62; comparing the threshold voltage and the sensor output voltage (after A/D conversion and filtering) by the edge detection circuits 63, 64, and 65; and then recognizing the center between the drop point at which the voltage drops below the threshold voltage first and the rise point at which the voltage rises above the threshold voltage first after the drop, as the pattern central position.

Next, the mode of the pattern used for the positional deviation correction, etc. is described with reference to FIGS. 5A to 5D. As depicted in FIGS. 5A to 5D, the pattern for the positioning control formed in the image forming apparatus 1 is different depending on the color mode used. The color mode can be selected by a user by the operation of the operation unit 34 (reception unit) in this embodiment, and the selection result is ordered to the writing unit 39 via the control unit 30. FIG. 5A depicts the pattern image for image quality adjustment for positioning control in the case of the five-color mode and FIG. 5B to FIG. 5D each depict the pattern image for image quality adjustment for positioning control in the case of the four-color mode.

In this embodiment, the total length of the pattern image for image quality adjustment for the positioning control in the sub-scanning direction is adjusted to be the length corresponding to the drive period of the carriage belt 105. The drive period is a period for which the carriage belt 105 makes a round. When the pattern length (from the start of the writing of the patterns to the start of writing of the next set of patterns) of one set of pattern images for the image quality adjustment is set to L [mm], the image processing unit 41 (calculation unit and image forming unit) forms the patterns so that N (N is an integer) times of the length L, i.e., L×N [mm] is equal to the drive period as the total pattern length. Therefore, in this embodiment, the L×N is set by the drive period first, and the same value is applied to each L regardless of whether the color mode is the five-color mode or the four-color mode. The method of adjusting the pattern intervals may be: forming the pattern image of the four-color mode by subtracting the unnecessary color from one set of pattern images of the five-color mode as depicted in FIG. 5B; or forming the pattern image while the interval of the toner marks is increased so that the total length of one set of pattern images is equal in the five-color mode and the four-color mode as depicted in FIG. 5C. In this case, as depicted in FIG. 5D, it is possible to prevent the total pattern length from being different when the four-color pattern image is formed at the same interval of the toner mark as that in FIG. 5A.

The relation between the drive period and the pattern image formed as above is described with reference to FIG. 6. Since the carriage belt 105 and the intermediate transfer belt for forming the pattern are driven to rotate, the rotation velocity periodically varies due to the influence of the deviation in belt thickness, the eccentricity of the rotation axis, etc. For suppressing the influence of the measurement error of the pattern position due to this periodic variation, the total length of the pattern is set to be the same as the length of one rotation of the carriage belt 105. The pattern image is formed by repeating the sets of the same patterns in the image processing unit 41, and the mean value of the positional deviation amount calculated for each set of the patterns is obtained. If the total pattern length after the repetition is equal to the drive period, the influence of the periodic variation can be reduced by taking the mean value.

In the image forming apparatus 1 of this embodiment, the total lengths of the pattern images for positioning control formed for each of the plural color modes are all matched; therefore, even though the positioning correction is performed on a certain color mode, the positional deviation due to the correction is difficult to occur because the total pattern length is the same in another color mode. Thus, the positioning correction can be performed as appropriate.

Since the total pattern length is set to match the drive period of the carriage belt 105, the influence of the measurement error of the pattern position caused by the variation in drive period can be suppressed.

Second Embodiment

The image forming apparatus 1 of a second embodiment has a feature of determining the total pattern length on the basis of the color mode with the largest number of colors. In general, as the number of colors increases, the number of toner marks included in the formed pattern increases. Therefore, if the total pattern length is determined based on the color mode with a small number of colors, the interval between the toner marks needs to be narrowed in the color mode having more colors than the mode used as the reference.

However, if the interval of the toner marks is narrowed, the overlapping between the toner marks is easily caused. Since the overlapping of the toner marks prevents the detection of the positional deviation, the maximal positional deviation amount that can be measured is reduced. In view of this, the total length of the pattern image is determined based on the color mode with the largest number of colors and set to L [mm] and the number of repetition times N is calculated; thus, the necessary and sufficient color positional deviation measurement range can be secured.

As for a specific method of calculating L and N, when the drive period of the carriage belt 105 is set to M, the minimal value, Lmin, of the length of one set of the pattern images is calculated by determining the pattern interval that can measure the necessary color positional deviation relative to the drive period. Next, by determining L and N so as to satisfy L>=Lmin and L×N=M, the pattern with the influence of the belt drive period reduced can be formed while securing the necessary color positional deviation measurement range.

Thus, by using such L and N, the pattern images of another color mode can also be generated.

Third Embodiment

Next, the image forming apparatus **1** of a third embodiment is described. In this embodiment, the total length of the patterns is determined based on the color mode which is assumed to be performed most frequently. FIGS. **7**A to **7**C depict the case in which the total length of the pattern image is set based on the four-color mode. If the proportion of the printing of the four-color mode is the largest, it is considered that the four-color mode is most frequently executed. Therefore, the image processing unit **41** determines the total length of the pattern in this mode as depicted in FIG. **7**A, and in another color mode, the pattern image is formed so that the length is equal to the total length of the pattern in the four-color mode as depicted in FIG. **7**B and FIG. **7**C.

By optimizing the pattern shape in accordance with the color mode which is most frequently executed, the image quality of the color mode which is most frequently executed can be corrected at high accuracy, and in another color mode, by performing the color matching control without changing the total pattern length, the minimal influence of the drive period can be reduced. As for the method of selecting the color mode which is most frequently executed, for example, the number of printed sheets is stored for each color mode and the color mode where the number of the stored sheets is the largest is selected as the mode which is most frequently executed. Alternatively, for each color mode, the pattern image is prepared which is based on each color mode, and in another color mode, the pattern is formed every time so that the total pattern length is equal to that of the pattern image of the selected color mode.

The present invention provides an effect that the appropriate positional deviation correction can be performed on any of a plurality of colors modes.

Although the invention has been described with respect to specific embodiments for a complete and clear disclosure, the appended claims are not to be thus limited but are to be construed as embodying all modifications and alternative constructions that may occur to one skilled in the art that fairly fall within the basic teaching herein set forth.

What is claimed is:

1. An image forming apparatus comprising:

an image former that forms a pattern for positional deviation correction on an image carrier;

a detector that detects the pattern for positional deviation correction;

a controller that controls a positional deviation correction process in accordance with a result of detection of the detector;

a receiver that receives a color mode selected from among a plurality of color modes, each having a different number of colors used for forming the pattern; and

circuitry configured to calculate a total pattern length so that a total length of the pattern for positional deviation correction in a sub-scanning direction is equal in any of the color modes, wherein the image former forms the pattern for positional deviation correction including the number of colors corresponding to the selected color mode so that the total length of the pattern for positional deviation correction is equal to the calculated total pattern length.

2. The image forming apparatus according to claim **1**, wherein the image former forms the pattern for positional deviation correction so that the total length of the pattern for positional deviation correction in the sub-scanning direction is equal to N times of a distance between a same color in the pattern for positional deviation correction in the color mode with the largest number of colors, N being a positive integer.

3. The image forming apparatus according to claim **1**, wherein the image former forms the pattern for positional deviation correction so that the total length of the pattern for positional deviation correction in the sub-scanning direction is equal to a length corresponding to one round drive of the image carrier.

4. The image forming apparatus according to claim **1**, wherein the image former forms the pattern for positional deviation correction so that the total length of the pattern for positional deviation correction in the sub-scanning direction is equal to N times of a distance between a same color in the pattern for positional deviation correction in the color mode which is executed most frequently, N being a positive integer.

5. The image forming apparatus according to claim **1**, wherein the detector includes first and second positioning sensors of the detector in a main-scanning direction which detect first and second positioning patterns, respectively, and

a proportion of a main-scanning magnification error is equal to $(D+B-A)/D$ in which A is a difference in millimeters between an ideal interval between horizontal line patterns and oblique line patterns of the first positioning pattern and a measured interval between the horizontal line patterns and the oblique line patterns of the first positioning pattern measured by the first positioning sensor, B is a difference in millimeters between an ideal interval between horizontal line patterns and oblique line patterns of the second positioning pattern and a measured interval between the horizontal line patterns and the oblique line patterns of the second positioning pattern measured by the second positioning sensor, and D is an interval in millimeters between the first and second positioning sensors.

6. The image forming apparatus according to claim **1**, wherein the color modes include a five-color mode and a four-color mode.

7. The image forming apparatus according to claim **6**, wherein the color modes further include a two-color mode.

8. An image forming method comprising:

forming a pattern for positional deviation correction on an image carrier;

detecting the pattern for positional deviation correction;

controlling a positional deviation correction process in accordance with a result of detection of the detecting;

receiving a color mode selected from among a plurality of color modes, each having a different number of colors used for forming the pattern; and

calculating a total pattern length so that a total length of the pattern for positional deviation correction in a sub-scanning direction is equal in any of the color modes, wherein the forming the pattern includes forming the pattern for positional deviation correction including the number of colors corresponding to the selected color mode so that the total length of the pattern for positional deviation correction is equal to the calculated total pattern length.

9. An apparatus comprising:

means for forming a pattern for positional deviation correction on an image carrier;

means for detecting the pattern for positional deviation correction;

means for controlling a positional deviation correction process in accordance with a result of detection of the means for detecting;

means for receiving a color mode selected from among a plurality of color modes, each having a different number of colors used for forming the pattern; and

means for calculating a total pattern length so that a total length of the pattern for positional deviation correction in a sub-scanning direction is equal in any of the color modes, wherein the means for forming form the pattern for positional deviation correction including the number of colors corresponding to the selected color mode so that the total length of the pattern for positional deviation correction is equal to the calculated total pattern length.

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